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ABSTRACT

A total of 27 figures is used to display information about (1) a scientific and technical (S&T) information transfer model, (2) United States S&T communication costs, and (3) U.S. S&T literature items. Figures dealing with communication costs include such variables as function, number of scientists or engineers, literature media, current and constant dollars, and process and control share of S&T communication costs. Figures dealing with S&T literature items give information on such variables as number of literature media types, prices in current and constant dollars, distribution, and number of subscriptions. (CMV)

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A Chart Book of Indicators of Scientific & Technical Communication in the United States

December 1977

Prepared by: King Research Inc.
Rockville, Md.

National Science Foundation
Division of Information Science
and Technology

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Foreword

The indicators of scientific and technical communication presented in the following charts are based on research supported by the National Sciences Foundation's Division of Science Information. This report summarizes selected findings in graphic form and provides a broad overview of the field. Details are available in three additional volumes that will be available from NTIS in the near future.

- Statistical Indicators of Scientific and Technical Communication (1960-1980) 1977 edition.
- Review of Scientific and Technical Numeric Data Base Activities.
- Statistical Indicators of Scientific and Technical Communication Worldwide.

In the third and final year of this effort, King Research, Inc. has begun to develop a detailed model of S&T communication in the United States. Comments on this report or related detailed reports may be useful in pursuing model building. Please direct comments to Helene Ebenfield, Division of Information Science and Technology or directly to King Research, Inc.

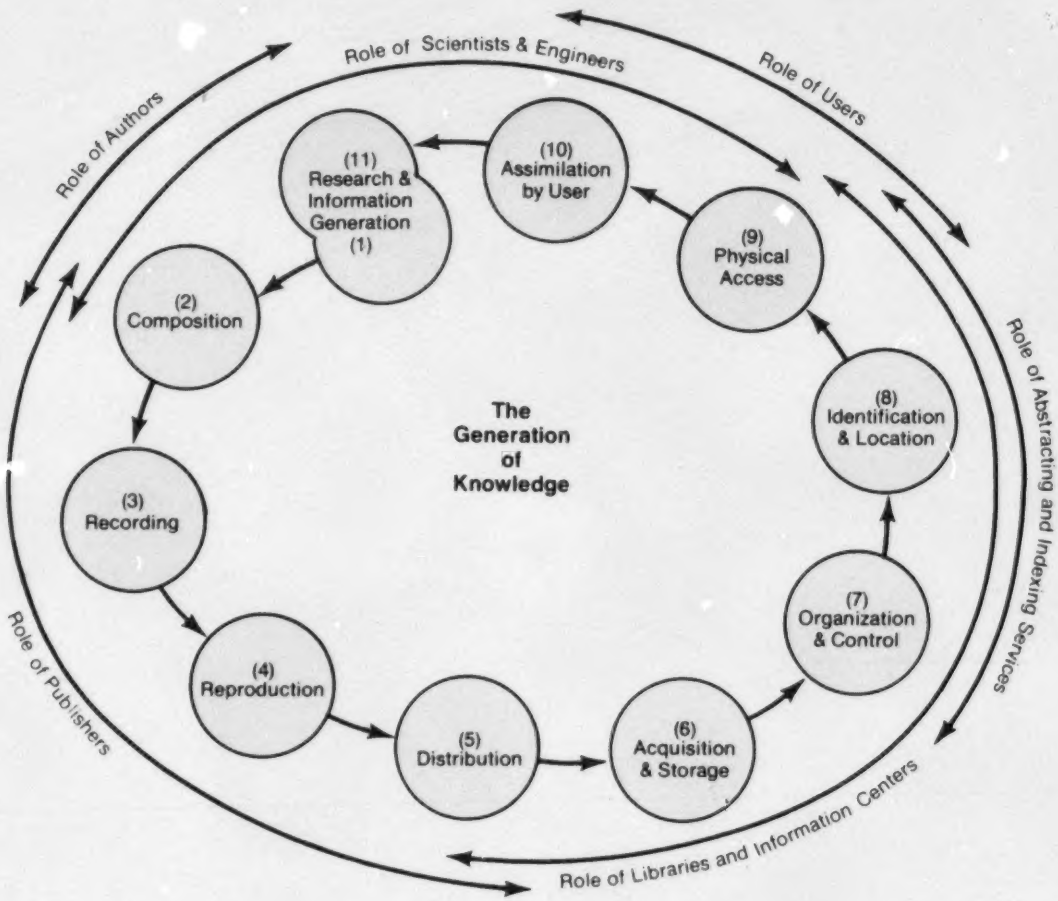
Lee G. Burchinal
Former Director
Division of Science Information
National Science Foundation

The data summarized in this Chartbook are the result of two years of research supported by the National Science Foundation under contract number DSI 75-06942, "Development of Statistical Indicators of Scientific and Technical Communication." When sources of data other than King Research, Inc. are utilized, the source is identified on the chart. Unless otherwise stated, all projections were made by King Research, Inc. This report was prepared by Donald W. King, Barbara L. Wood and Charles G. Schueller. Any opinions, findings, and conclusions expressed herein are those of the authors and do not necessarily reflect the views of the National Science Foundation.

■ The transfer of scientific and technical information is depicted as a spiral containing a sequence of functions performed by groups of participants. In this view, scientists and engineers are both authors and end users of information. Publishers, libraries, information centers, indexing and abstracting services perform the various functions associated with documentation, dissemination, bibliographic control, storage, and access. Although this model applies particularly to the transfer of printed information, the same functions in combination, or by reordering, also apply to communication in micrographic and electronic forms.

Figure 1

Scientific and technical information transfer model



SOURCE: King Research, Inc., 1977

■ Scientific and technical (S&T) communication costs grew from $2 billion in 1960 to $10 billion in 1975. Projected to 1980, S&T communication expenditures reach $16 billion. Not included in these costs are substantial expenditures associated with the collection, storage and use of numeric data bases. Federally operated numeric data activities alone would add over $900 million dollars to the amounts expended in 1975.

Between 1970 and 1975, S&T communications costs increased 70 percent, more than either the GNP at 54 percent, or R&D funds at 33 percent. Projections to 1980 indicate that S&T communication costs will slow to a 65 percent increase over 1975, while both the GNP (75 percent) and R&D funds (50 percent) will grow at increasing rates over the previous five-year period.

Figure 2

S&T communication costs, in current and constant dollars (1960-1980)

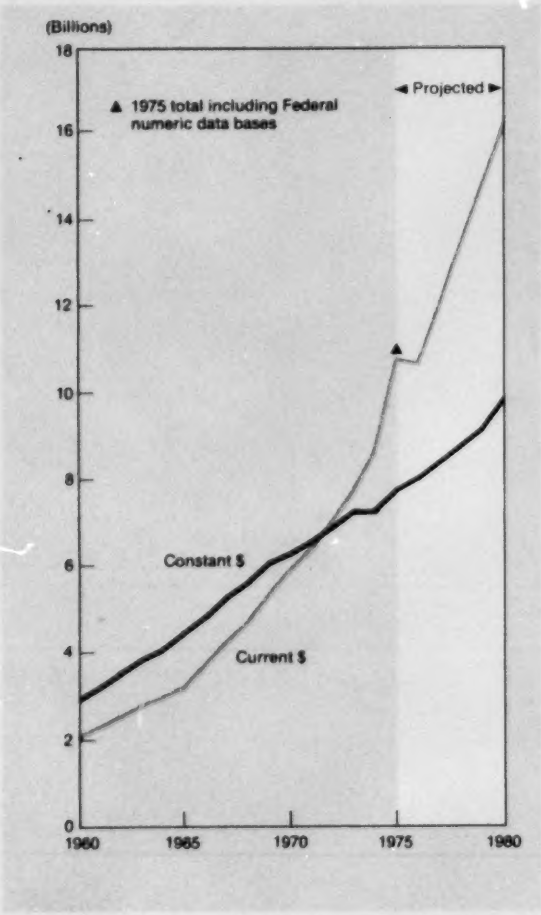
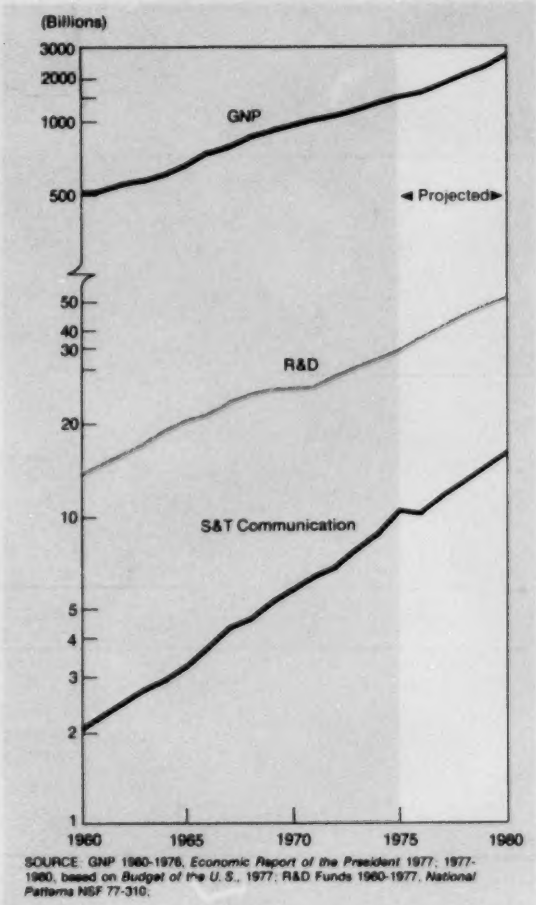


Figure 3

Gross national product, research and development funds, and S&T communication costs, in current dollars (1960-1980)



SOURCE: GNP 1960-1976, *Economic Report of the President* 1977; 1977-1980, based on *Budget of the U.S.*, 1977; R&D Funds 1960-1977, *National Patterns* NSF 77-310.

In 1975, there were just over 2 million scientists and engineers in the United States. Slightly more than half (1.1 million) are engineers. Life, social and physical scientists account for about 10 percent each. The remainder in decreasing numbers are computer scientists, psychologists, mathematical, and environmental scientists. A net addition of more than 50 thousand scientists and engineers is expected every year through 1980.

When S&T communication costs are divided by the number of scientists and engineers in each year, it is apparent that the investment per scientist or engineer for S&T communication is steadily increasing, even in constant (1972) dollars. While, in 1960, this constant-dollar amount was $2,500 per person; by 1975 it had grown to $3,900. This rise in constant dollars will increase to $4,200 by 1980.

Figure 4

Estimated number of scientists and engineers (1960-1980)

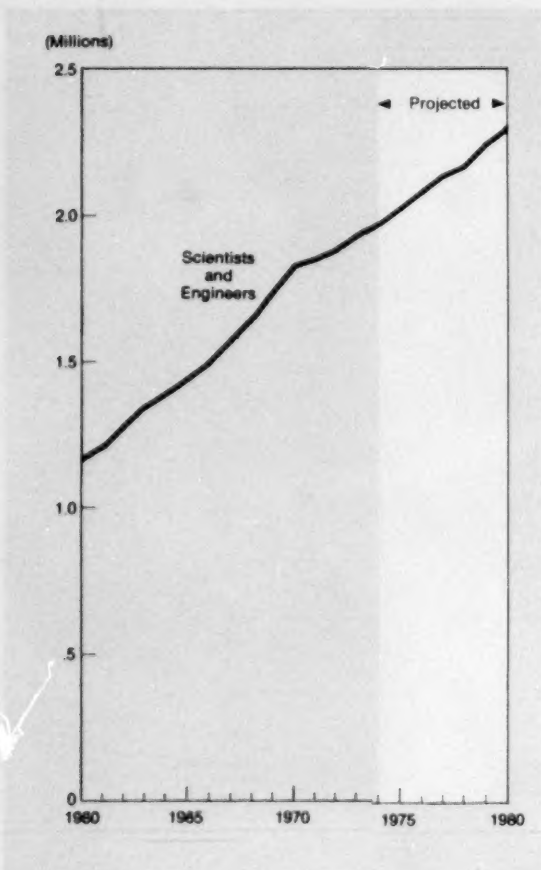
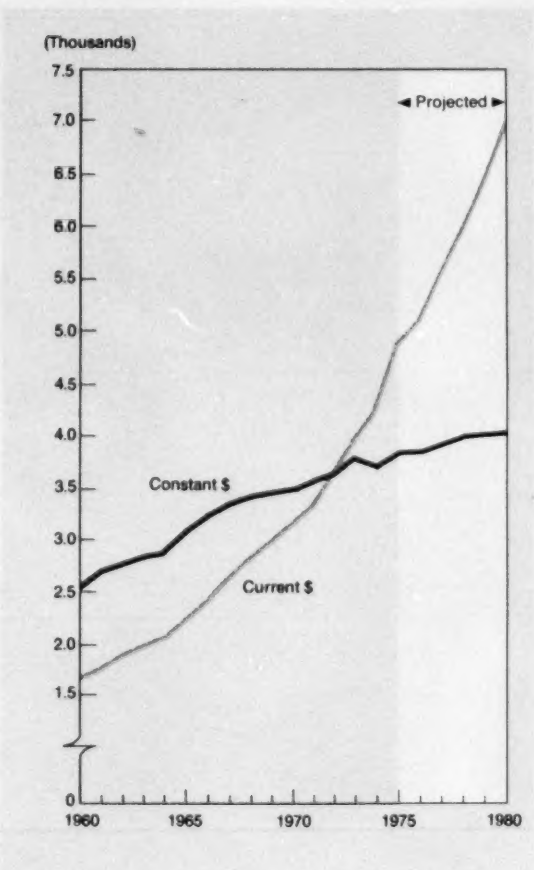


Figure 5

S&T communication costs per scientist or engineer, in current and constant dollars (1960-1980)



■ Costs of S&T communications have risen steadily since 1960. Current-dollar costs are expected to rise at a more rapid rate between 1975 and 1980 than previously. Costs for the four functional areas have also experienced a steady rise, with this trend expected to continue through 1980, even in constant dollars. Use costs, the dominant functional area, are made up primarily of the costs of the time spent by scientists and engineers in reading. Process and control includes the operations of libraries, information centers, abstracting and indexing services and similar activities. Publication costs include all those associated with editing, publishing and subscription distribution. Authorship, like use, is largely a cost function comprised of scientists' and engineers' time, but also includes staff and reviewer support.

Figure 6

S&T communication costs by function, in current dollars (1960-1980)

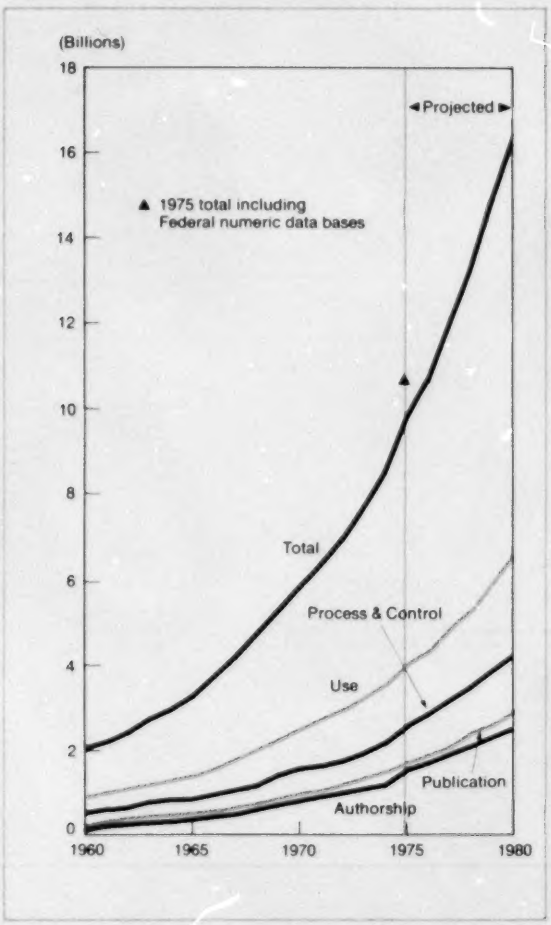
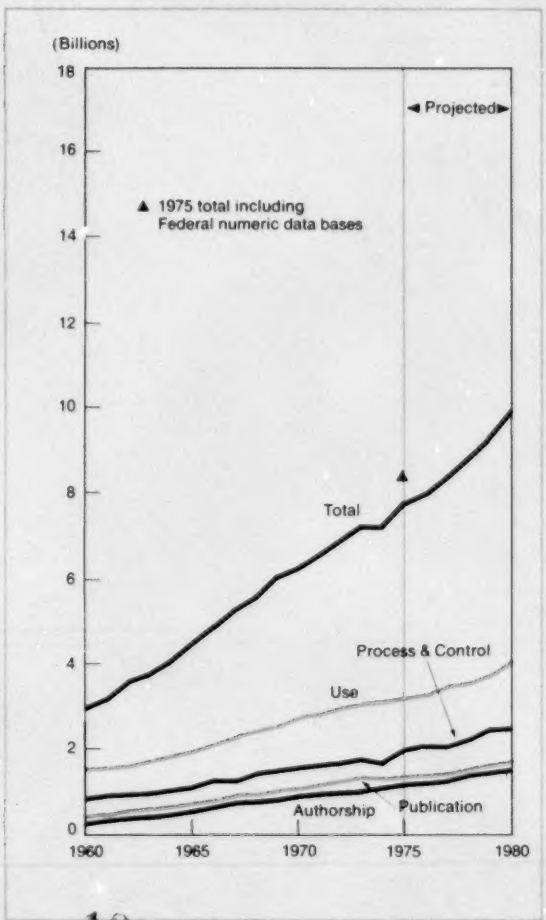


Figure 7

S&T communication costs by function, in 1972 constant dollars (1960-1980)

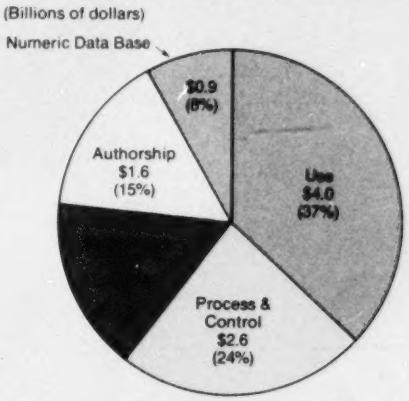


10

The expenditures associated with the use of S&T information account for the largest proportion of all S&T communication costs. At $4.0 billion in 1975, "Use" amounted to 37 percent of total expenditures. The next most costly function was process and control with $2.6 billion and 24 percent. Authorship and publishing accounted for more than $1.5 billion each in the same year.

Figure 8

S&T communication costs by function, 1975



Periodical literature has maintained its approximately two-thirds share of S&T communication costs since 1960 and is expected to continue to do so, when reaching $11 billion in 1980. Books appear to be accounting for a slightly decreasing share of total costs. While book costs have exceeded 25 percent of the total since 1960, by 1980 they will account for only 22 percent. Reports and other literature forms combined have not accounted for more than 8 percent since 1960.

Figure 9

S&T communication costs by medium, in current dollars (1960-1980)

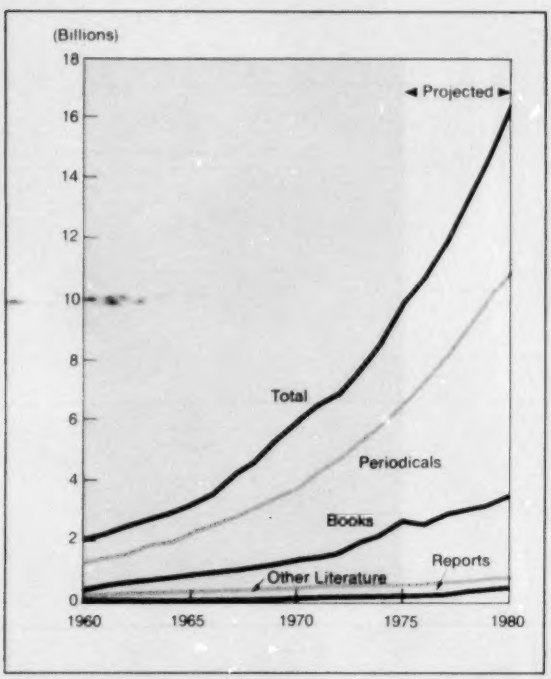
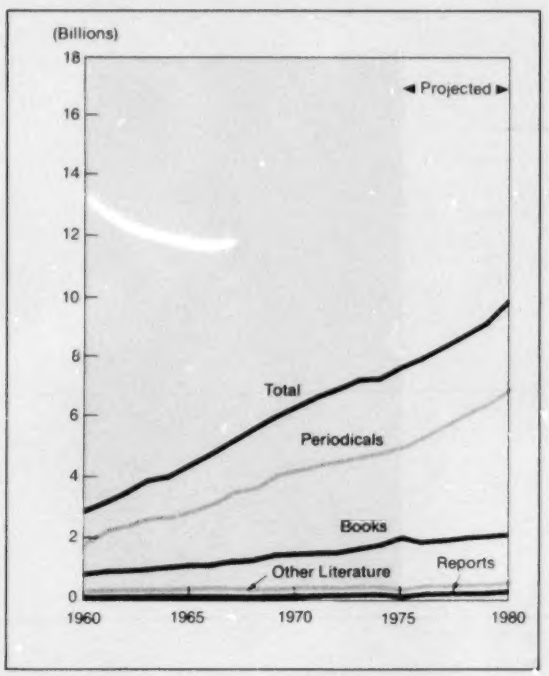


Figure 10

S&T communication costs by medium, in 1972 constant dollars (1960-1980)

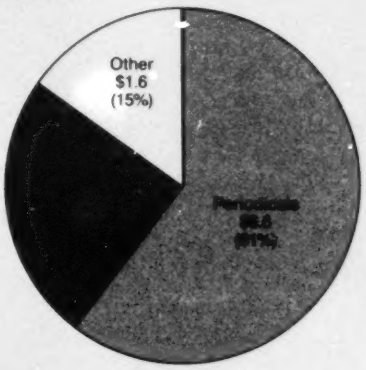


■ Scientific and technical periodicals account for almost two-thirds of S&T costs. While the creation, handling and use of S&T periodicals cost almost $7 billion in 1975, books accounted for less than half as much, $3 billion. The $1 billion for all other media was almost equally divided between reports and other forms, including patents and dissertations.

Figure 11

S&T communication costs by medium, 1975

(Billions of dollars)



■ S&T communication resource expenditures attributed to scientists and engineers as both authors and users of information amounted to $5.6 billion in 1975. The largest portion of this amount was for the authorship and reading of periodical articles. Total process and control function costs for S&T communication resources amounted to $2.6 billion, and again over 60 percent is attributed to the handling of periodical literature. Books were the second most costly medium in both cases, 25 percent for scientists and engineers, 35 percent for process and control.

Figure 12

Scientists' share of S&T communication costs, by medium, 1975

(Millions of dollars)

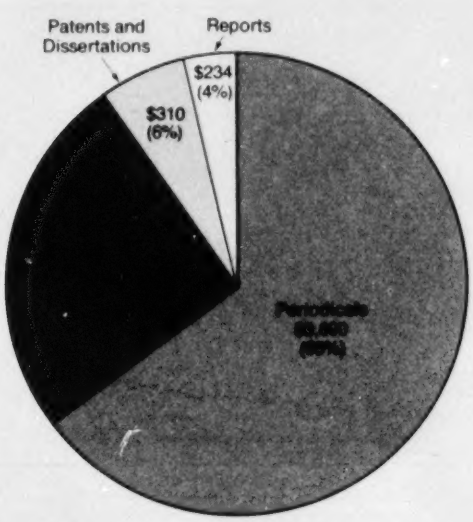
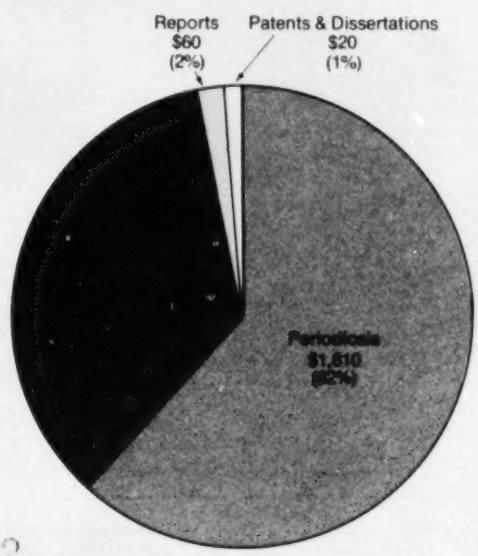


Figure 13

Process and control share of S&T communication costs, by medium, 1975

(Millions of dollars)



The number of scientific and technical periodical titles increased 25 percent between 1960 and 1970. Growth has slowed somewhat, and number of titles projected to 1980 shows an 18 percent increase in the latter decade. Of the several kinds of periodicals, journals predominate. They accounted for 44 percent of S&T periodicals in 1960, 46 percent in 1970 and are expected to exceed 50 percent by 1980. On the average, each journal published seven issues in 1975, so that the number of issues is greater than the number of book titles, although it is still less than the number of technical reports. The number of book titles increased less than the number of technical reports. The number of book titles increased dramatically in the decade ending in 1970, 245 percent. This growth rate is slowing substantially, and for the decade following 1970, is projected at only 41 percent.

When the production of literature items is compared to the number of scientists and engineers, some types of items show a fairly constant rate of production since 1960, while others have changed substantially. Relatively level rates have been experienced for journal articles (between 140 and 160 per 1,000 scientists or engineers) and patents (40-45 per 1,000). Slightly decreasing rates were experienced by journals (about 2 per thousand scientists or engineers) and periodicals (4-5 per 1,000). Increasing rates have occurred for books, dissertations and technical reports. Production of these items has risen faster than has the number of scientists or engineers.

For Figure 14

Source: *The Bowker Annual of Library and Book Trade Information*, R.R. Bowker Company, (Books, 1960-1974); *Dissertations Abstracts International* (Dissertations, 1960-1974); King Research, Inc., 1977 (Journals, 1960-1980; All Others, 1975-1980); National Technical Information Service (NTIS Reports, 1960-1974); *Statistical Abstract* (Patents, 1960-1974)

Figure 14

Number of U. S. S&T literature items, by medium (1960-1980)

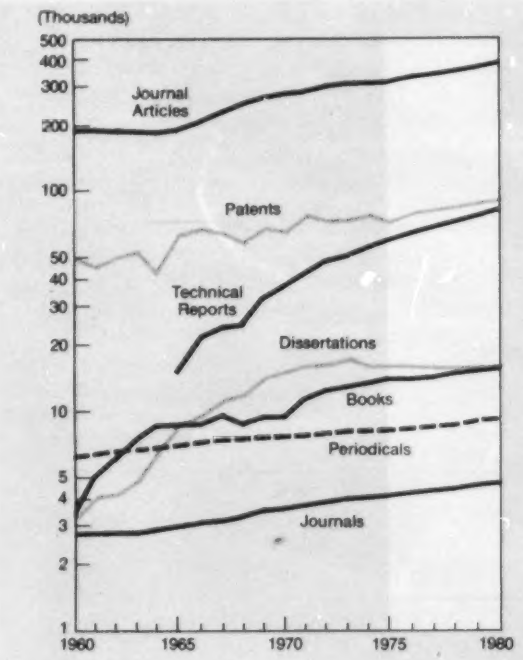
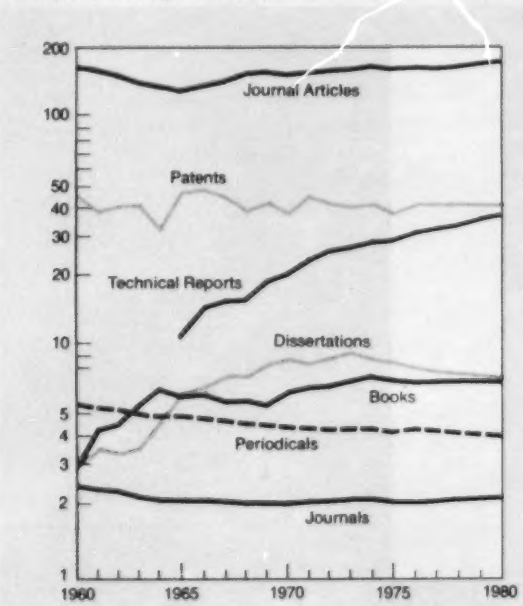


Figure 15

Number of S&T literature items per 1,000 scientists or engineers, by medium (1960-1980)



■ Publication of S&T books has grown from 3,500 titles in 1960 to almost 14,500 in 1975, with the fastest rate of growth in the period 1960-65, and generally slowing growth rates in the 5-year periods since. The estimate for number of titles in 1980 is 16,500.

Scientific and technical works in sociology and economics predominate when titles are examined by discipline. Science, medicine and technology also have substantial shares of 20, 16 and 12 percent respectively. Psychology and agriculture are less important in their shares of book titles with only 5 and 2 percent respectively.

Figure 16
S&T book titles published (1960-1980)

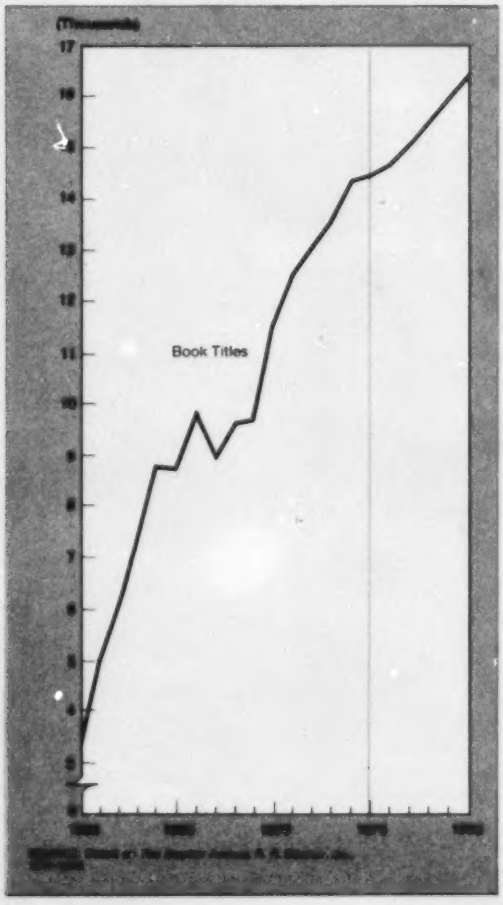
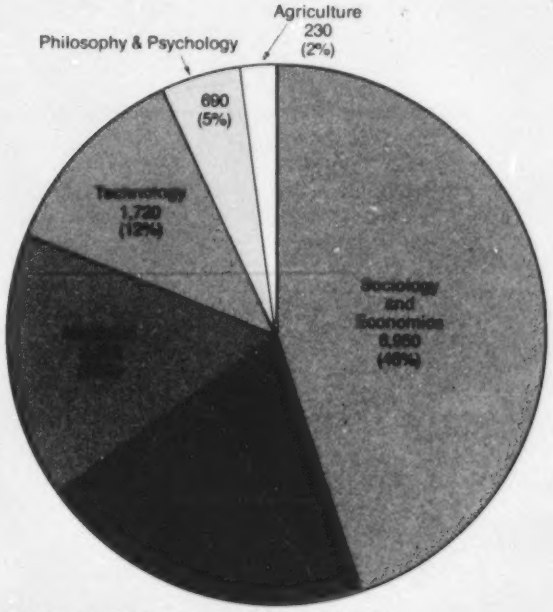


Figure 17
Distribution by subject of 14,400 S&T book titles published in 1975



SOURCE: Based on *The Bowker Annual*, R. R. Bowker, Co., 1976.

14

■ Approximately three years elapses between the preparation of a book manuscript and its final publication. Estimates of book generation rates for scientists and engineers, therefore, can be calculated by dividing the number of S&T book titles published in a given year by the number of scientists and engineers three years earlier. While rates rose rapidly between 1960 and 1964, the rate has been more even since then. Almost eight books were generated in 1975 for every 1,000 scientists or engineers.

In terms of 1972 constant dollars the price per S&T book copy has remained fairly level since 1960, with only slight variations. The current-dollar price has increased substantially since 1973 and is expected to continue this rise through 1980. The average S&T book cost $17 in 1975 and is projected to cost $21 in 1980.

Figure 18

Number of S&T book titles published per 1,000 scientists or engineers (1960-1980)

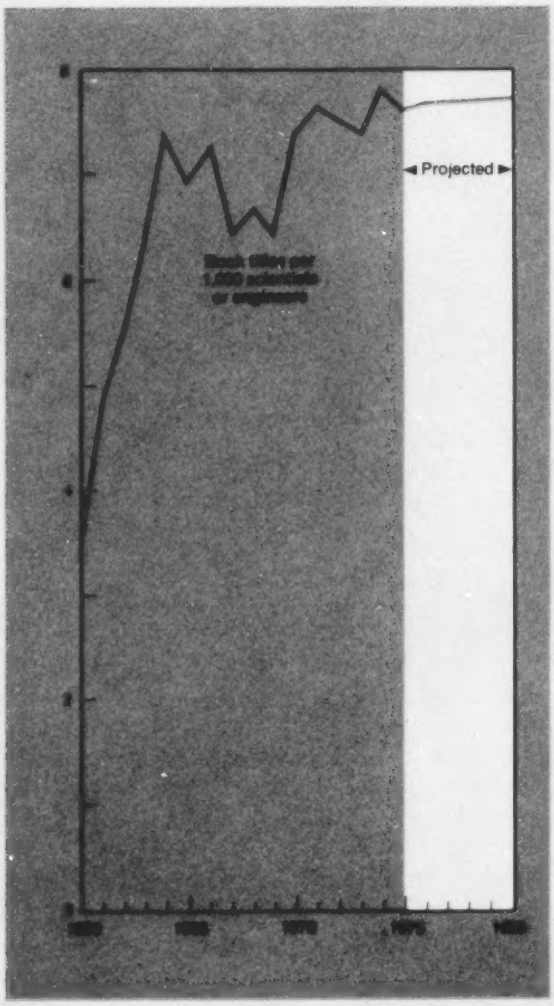
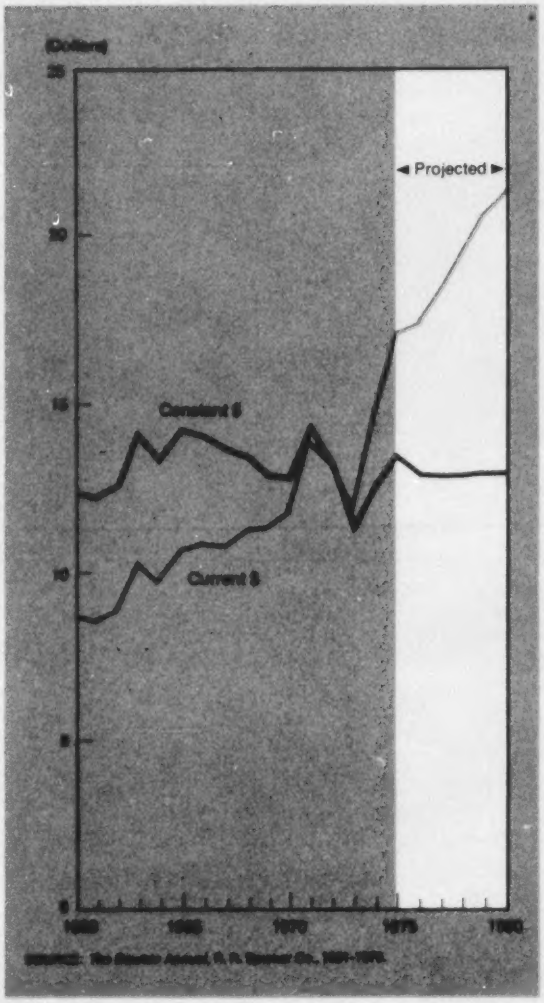


Figure 19

Average S&T book price, in current and constant dollars (1960-1980)

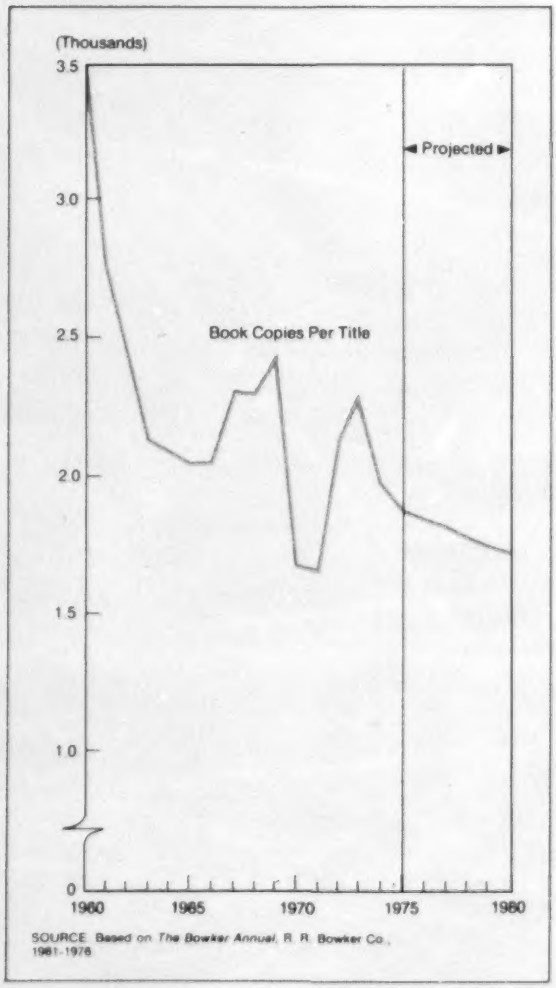


■ Although the number of book titles has been increasing fairly consistently since 1960, sales per title have generally decreased, averaging 1,900 in 1975, down from 3,400 in 1960. A drop to 1,700 by 1980 is anticipated.

The rate of purchase of science and engineering books peaked in 1973 at 16 copies per scientist or engineer. By 1975, this number had dropped below 14. If this drop continues, by 1980 the average number of copies sold per scientist or engineer will be less than 13.

Figure 20

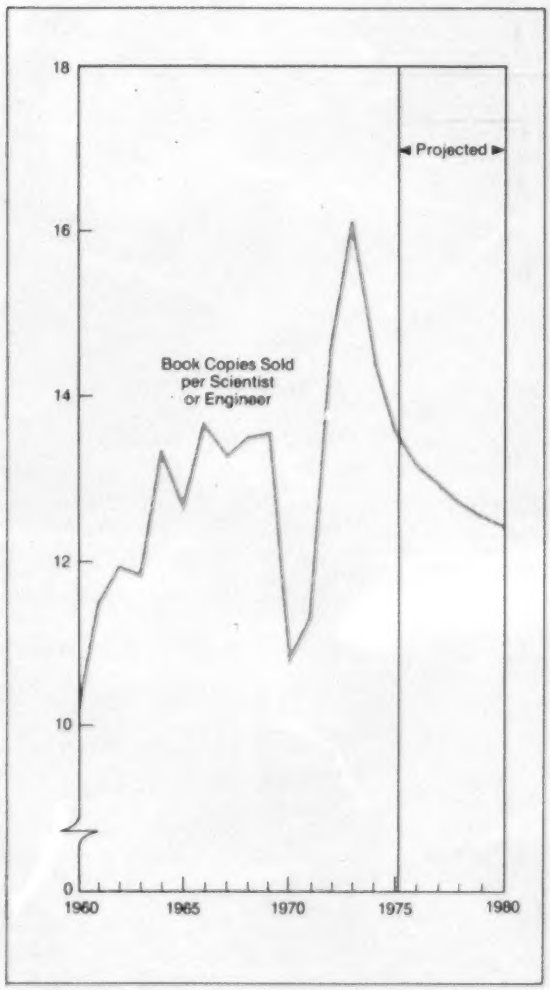
S&T book copies sold per title (1960-1980)



SOURCE: Based on *The Bowker Annual*, R. R. Bowker Co., 1961-1976

Figure 21

S&T books sold per scientist (or engineer (1960-1980)

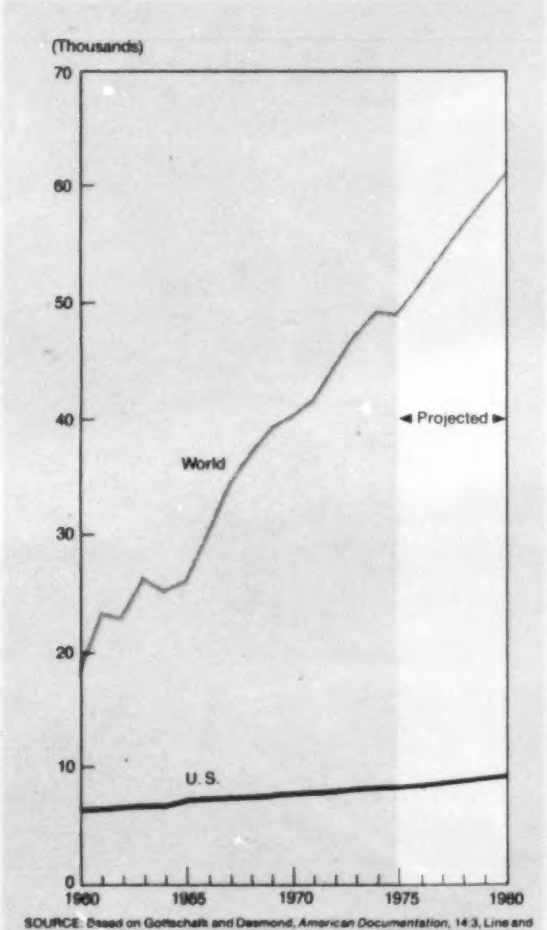


■ The United States is publishing a decreasing share of the World's S&T periodicals. While U.S. publishing accounted for 34 percent in 1960, it had decreased to 17 percent by 1975. Projections to 1980 indicate a further decrease to 15 percent.

About half of the U.S. published S&T periodicals are journals. This proportion has remained fairly stable since 1960. The remaining periodicals include trade publications, newsletters, etc. About half of the journals are "Scholarly Journals," a category which includes the primary refereed S&T journals published in the United States.

Figure 22

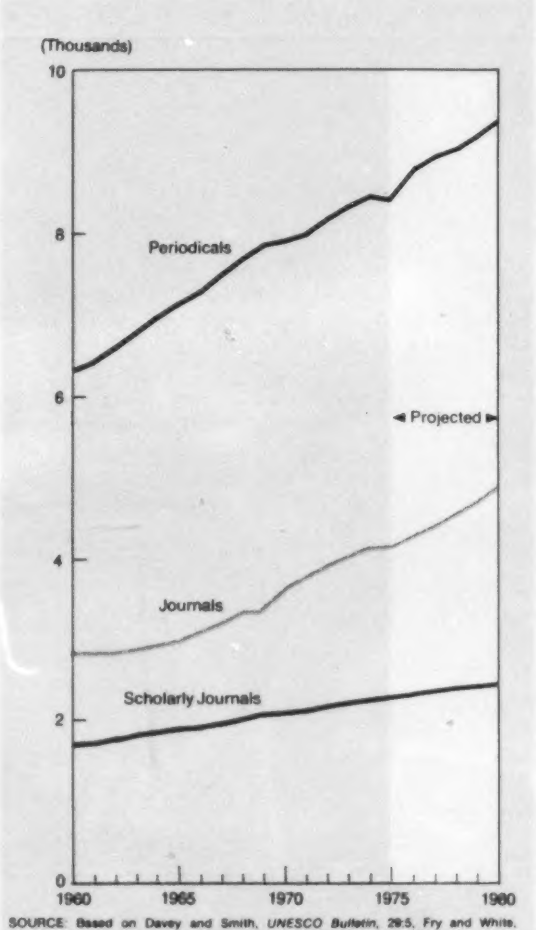
Number of world and U. S. S&T periodicals published (1960-1980)



SOURCE: Based on Gottschalk and Desmond, *American Documentation*, 14:3, Line and Wood, *Journal of Documentation*, 31:4; Davey and Smith, *UNESCO Bulletin*, 29:5.

Figure 23

Number of U. S. S&T periodicals, journals and scholarly journals published (1960-1980)

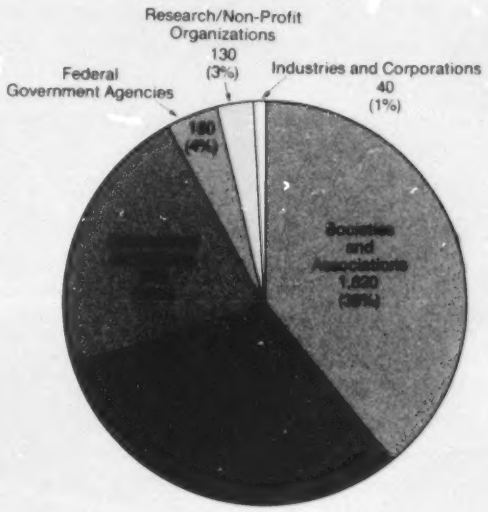


SOURCE: Based on Davey and Smith, *UNESCO Bulletin*, 29:5, Fry and White, *Economics and Interaction of the Publisher-Library Relationships*, 1975.

■ Publishers of U.S. S&T journals are mostly scientific associations, commercial publishing houses or educational institutions. Only 8 percent of U.S. journals are published by a combination of Government agencies, industry and nonprofit research organizations. Although a substantial proportion of all articles published result from federally-funded research activities, the Government is not a primary publisher of the resulting articles, but is the primary publisher of technical reports which result from the same research endeavor.

Figure 24

Distribution by publisher type of 4,200 U. S. S&T journals published in 1975

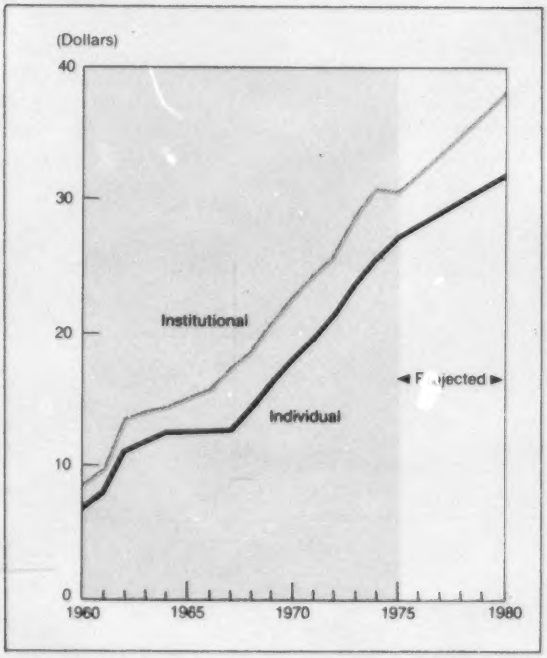


■ Annual institutional prices for U.S. S&T journals are projected to continue increasing at a fairly stable rate through 1980.

Average annual individual subscription prices for U.S. S&T journals over the same period show increases similar to those experienced by institutional prices. In 1975, institutional prices averaged $30.47 and individual prices more than $3.00 less at $27 20.

Figure 25

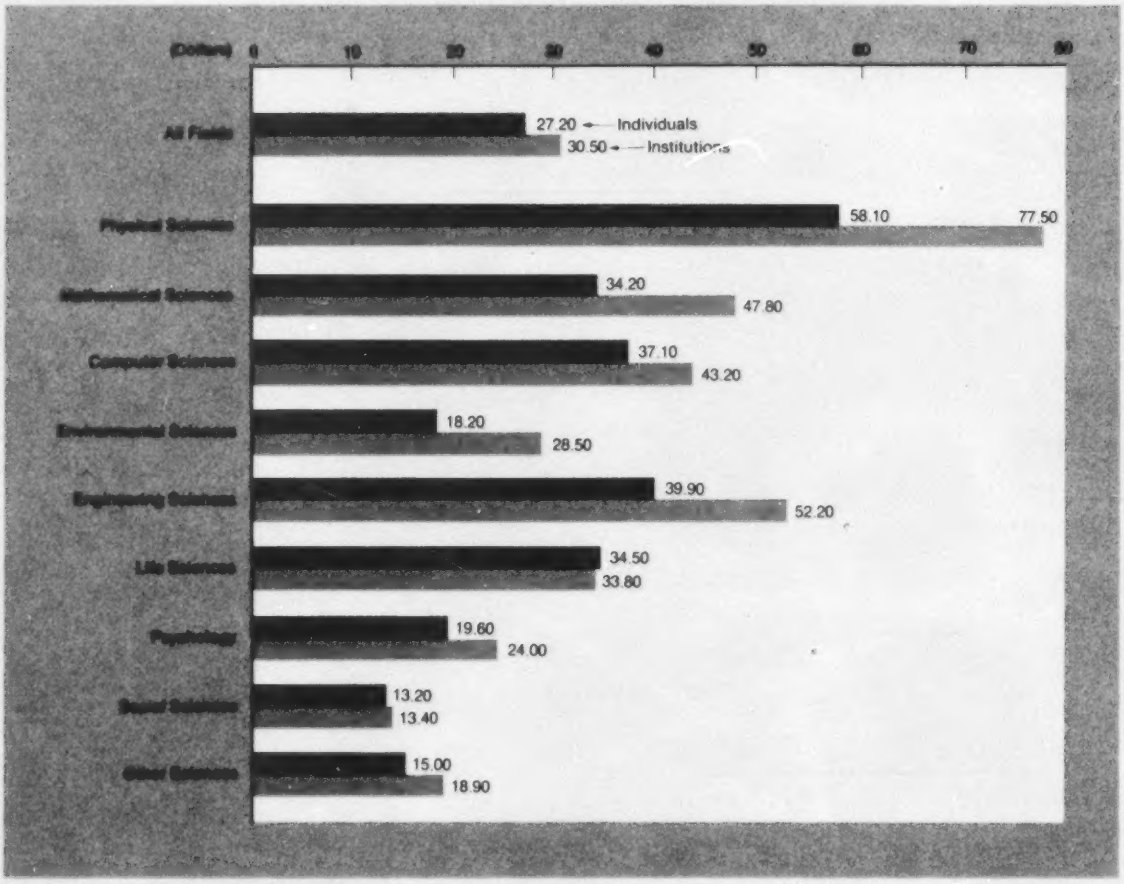
Average annual individual and institutional subscription prices for U. S. S&T journals (1960-1980)



■ Subscriptions to S&T journals cost less for individuals than for institutions such as libraries, although the difference is not great for all fields. More substantial differences in subscription costs are observed between fields. Physical science journals are the most costly and also have the largest difference between individual and institutional prices. Conversely, journals in the social sciences are the least costly and are almost identically priced for individuals and institutions.

Figure 26

Average S&T journal subscription prices for individuals and institutions, by field, 1975

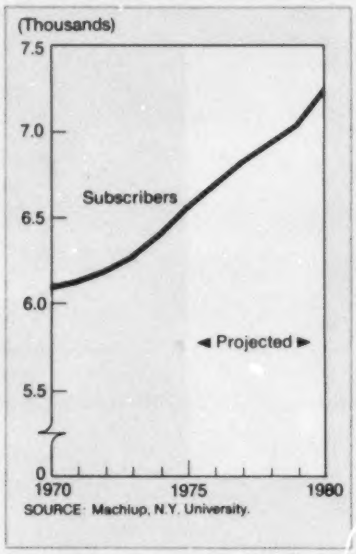


■ The average number of subscribers to an S&T journal increased only slightly between 1970 and 1972, then rose more sharply to 6,500 in 1975. A continuation of this increase will bring average subscriber levels to over 7,200 by 1980. Circulation of S&T periodicals other than journals is more than twice as large, 18,600 in 1975.

Circulation of both journals and other periodicals varies considerably by field. For most fields, the average number of subscribers is lower for journals than for other types of periodicals (trade publications, newsletters, etc.). Smallest journal circulation is found in social sciences and psychology, largest in computer sciences. For other periodicals, small circulation occurs in psychology and the physical sciences. Engineering and environmental sciences have larger than average circulation for the other periodicals. Of the identified fields, only computer scientists make more use of journals than of other periodicals. For all fields, the circulation of journals was only 35 percent of circulation of other periodicals.

Figure 27

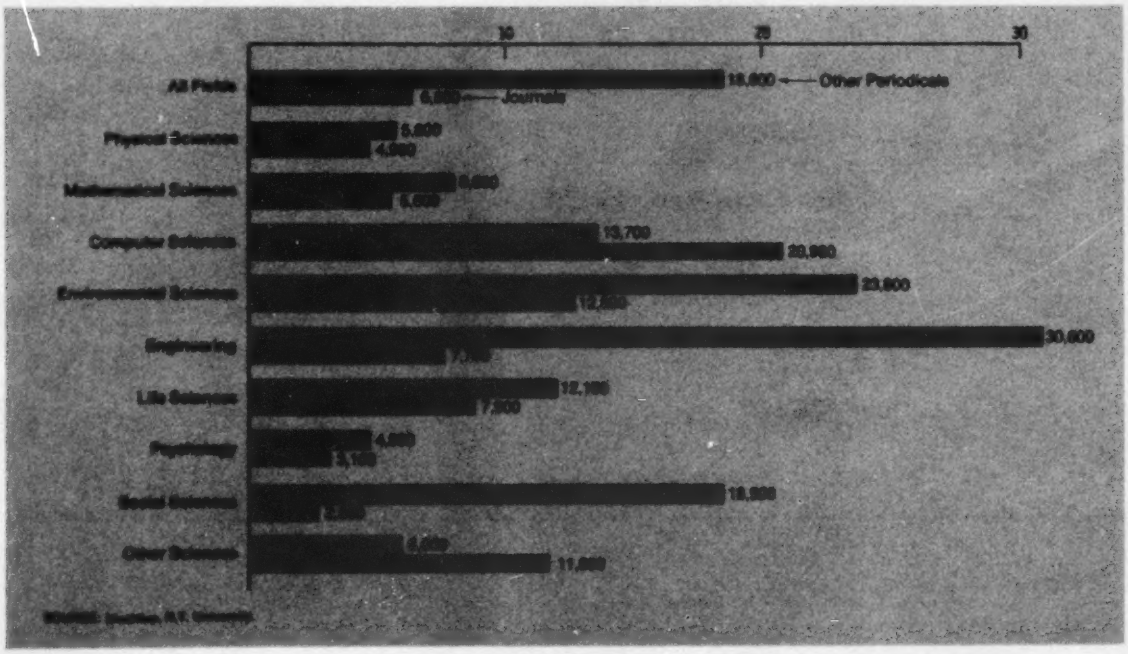
Number of subscribers per S&T journal (1970-1980)



SOURCE: Machlup, N.Y. University.

Figure 28

Average circulation of S&T journals and other periodicals, by field, 1975



■ Since 1965, the average annual articles per S&T journal has increased from 66 to 78. Thus the increase in the number of journals has yielded an even more rapid rise in the number of articles. Between 1960 and 1970 the number of articles rose only 33 percent. By 1980, the increase over a decade is estimated at 100 percent.

In 1975 three-quarters of all journal articles were in four fields: life, physical and social sciences and engineering. Life sciences alone accounted for one-third.

Figure 29
Number of U. S. S&T journal articles (1960-1980)

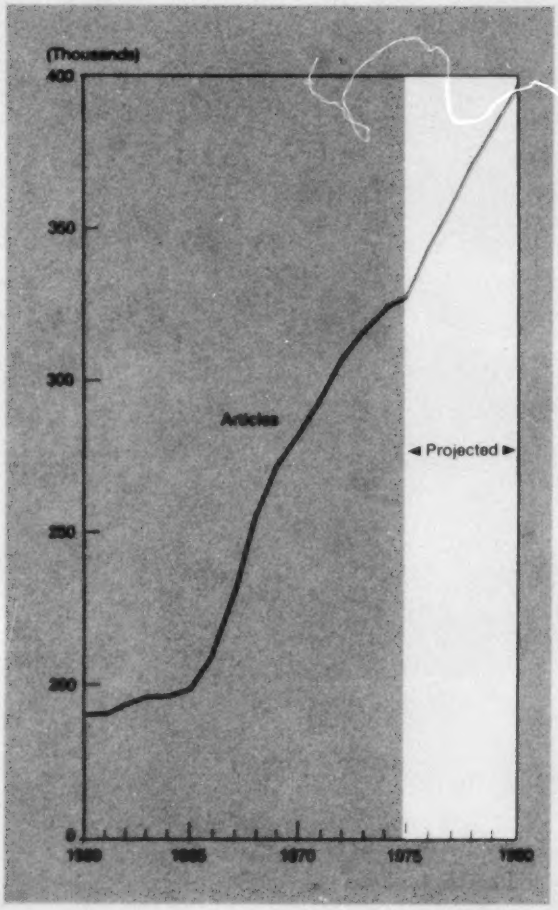
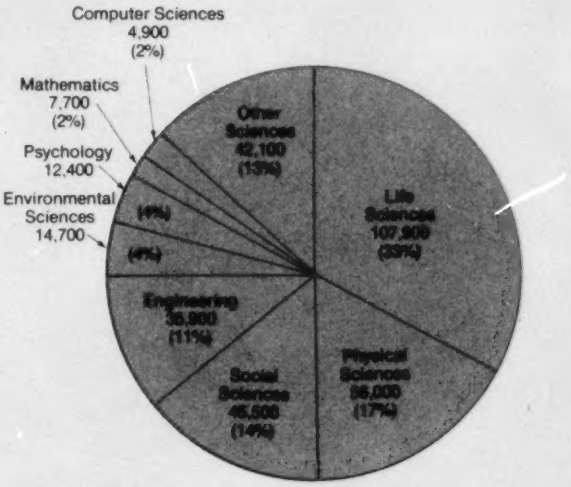


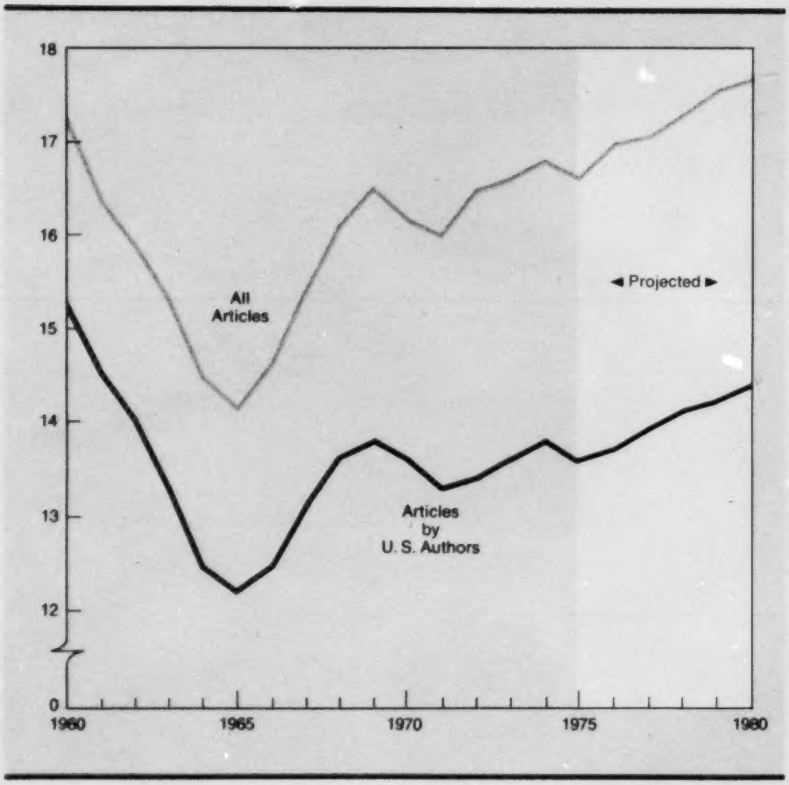
Figure 30
Distribution of 327,000 S&T journal articles, by field, 1975



■ The rate per scientist or engineer at which journal articles are published has been increasing steadily since the mid-1960's, a change from the downward trend between 1960 and 1965. As it takes about one year for an article to be published, this rate is derived by dividing articles published in a current year by the number of scientists and engineers in the previous year. In 1975, about 17 articles were published for every 100 scientists or engineers in the population. This generation rate is lower if only articles in U.S. S&T journals which are written by U.S. authors are considered. Although this lower rate, about 14 articles per 100 scientists or engineers in 1975, discounts the impact of articles in U.S. journals by foreign authors, it does not take into account articles by U.S. authors which appear in foreign journals.

Figure 31

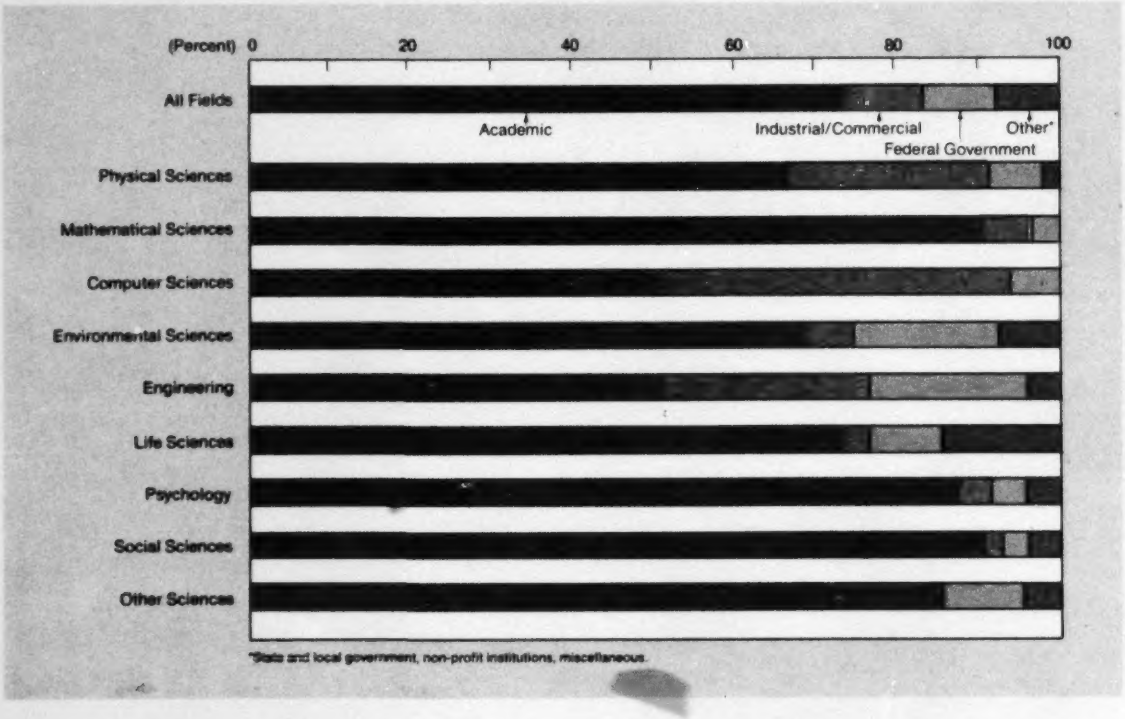
Number of U. S. S&T journal articles published per 100 scientists or engineers (1960-1980)



■ In 1975, the vast majority of U.S. authors of S&T journal articles reported academic affiliation. In the mathematical and social sciences the proportion of authors reporting academic affiliations exceeded 90 percent. Computer science authors reported having the highest proportion of industrial/commercial affiliations (43%), demonstrating the important role that computers play in private industry. Those fields showing the lowest proportion of industrial/commercial affiliations (i.e., psychology, 4%, social sciences, 2%) are those least related to research and development and manufacturing. The highest proportion of Federal government affiliations were reported in the fields of environmental sciences and engineering (18%, 19%), while the lowest reported occurred in social sciences and mathematics (3%, 4%). The mathematical and computer sciences showed no authors reporting "other" affiliations while the largest proportion of "other" affiliations reported occurred in the life sciences (15%). This is likely due to the large number of scientists who are involved in medical professions and work for research institutions and non-academic hospitals.

Figure 32

Distribution of S&T journal articles by author's institutional affiliation and field, 1975



■ Almost one quarter of authors of S&T journal articles pay page charges. Substantial differences exist by discipline, with more than half of authors of engineering articles paying such charges. Social scientists rarely pay page charges.

The amounts paid for an article can be averaged for those who pay such charges or, alternatively, for all authors. Although computer and environmental scientists are not as likely as physical scientists or engineers to pay any charge, when they do, their cost is about $80 higher.

Figure 33

Percent of S&T authors paying page charges, by field, 1975

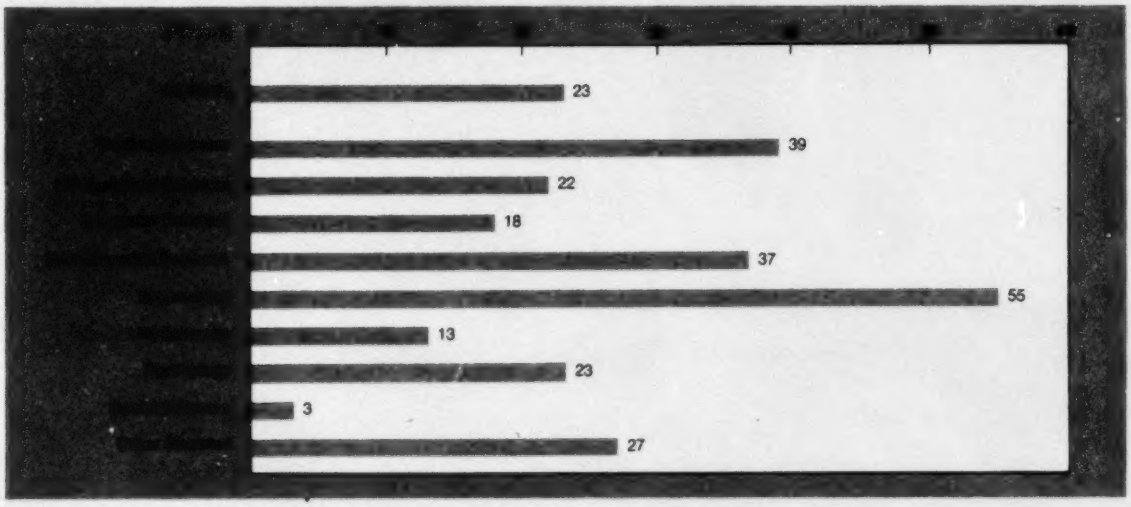
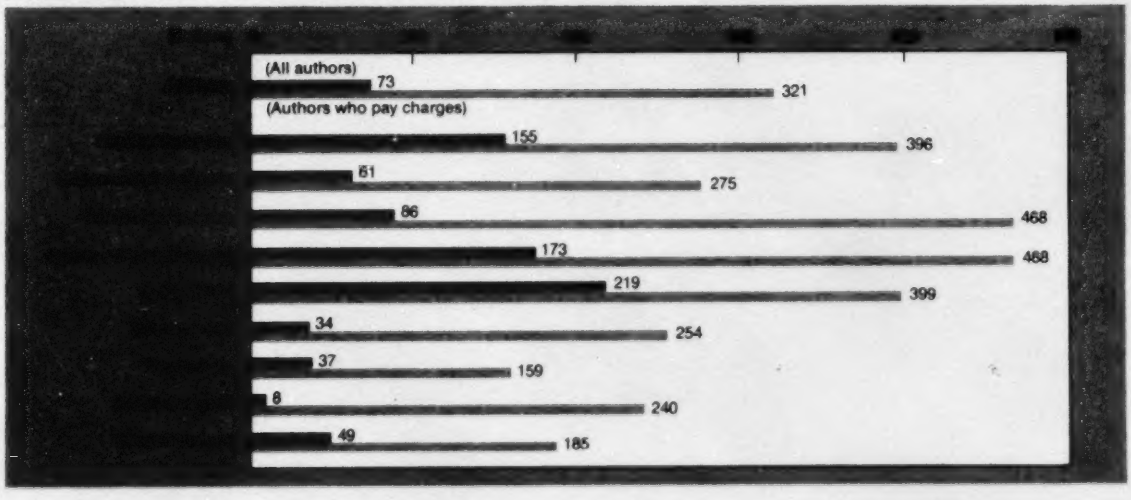


Figure 34

Page charges paid per S&T article, by field, 1975



■ Over 95 percent of the 60,200 technical reports published by the Government Printing Office and the National Technical Information Service were processed by NTIS alone. An additional two percent were published through GPO, and three percent were published by both organizations.

Copies of GPO reports have a substantially larger share in distribution, as 45 percent of all copies sold were purchased through GPO. While these sales were all paper copies, NTIS sales were predominantly microfiche which totalled 42 percent of all copies sold.

Figure 35
60,200 technical reports processed by NTIS and GPO in 1975

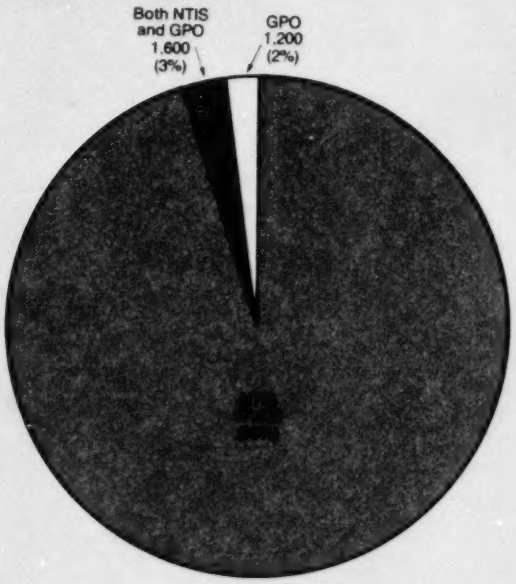
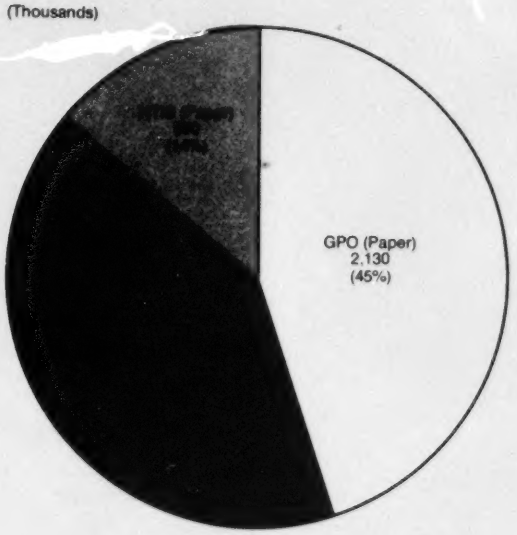


Figure 36
4,800,000 copies of technical reports sold by NTIS and GPO in 1975

(Thousands)



■ Selected types of libraries; public, special, and academic, generally increased in number only slightly between 1963 and 1973. More dramatic growth in the population of special libraries, however, occurred between 1973 and 1976. While no expenditure information was available for these special libraries, combined expenditures for S&T communication by public, academic and Federal libraries show a steady increase since 1960. Current-dollar expenditures will continue to rise until almost the end of the 1970's, although constant-dollar expenditures will level out somewhat.

Figure 37

Growth in number of libraries, by selected type (1960-1980)

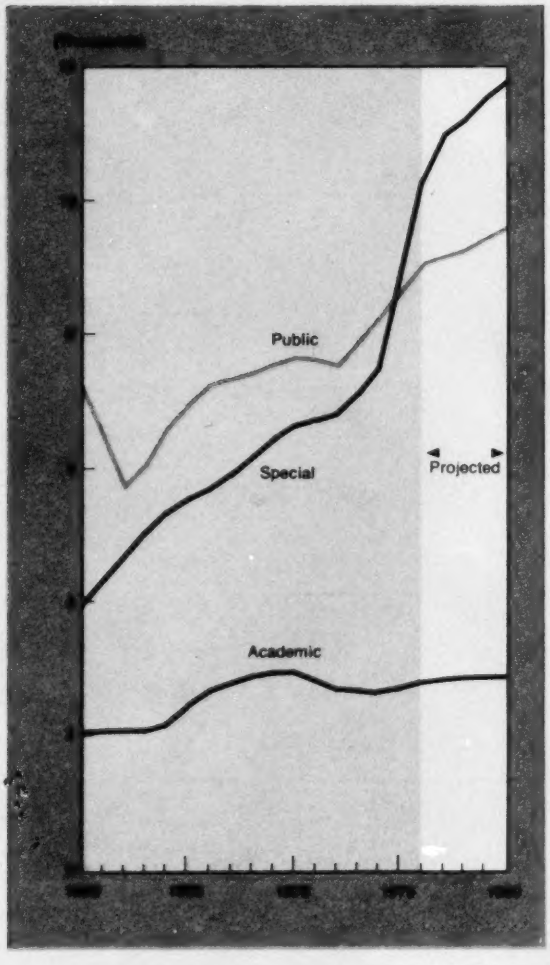
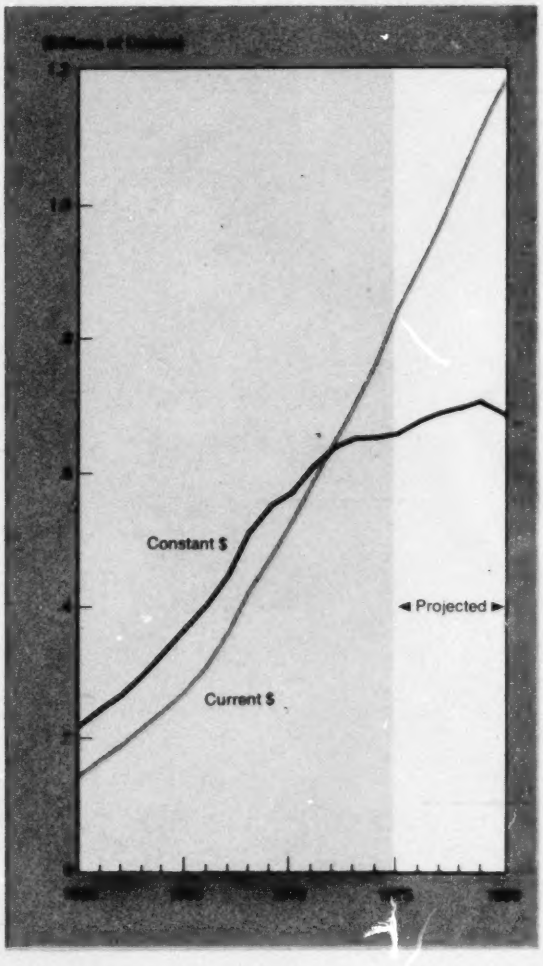


Figure 38

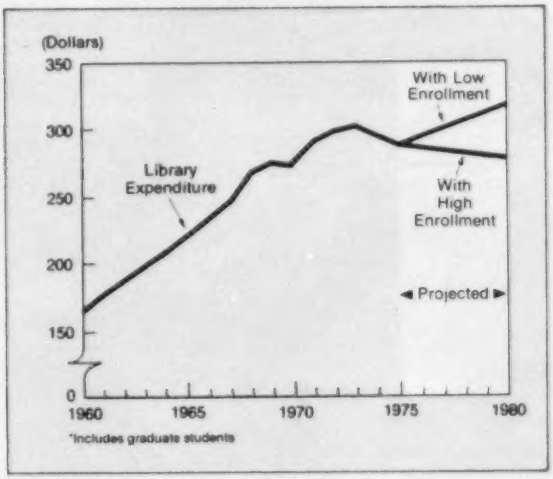
Growth in S&T communication expenditures by academic, public and Federal libraries, in current and constant dollars (1960-1980)



Libraries were spending increasing constant-dollar amounts on S&T information per scientist or engineer through about 1973, when the mean cost began to drop. The scientist and engineer population for this graph includes science and engineering students enrolled for advanced degrees. Alternate projections for these enrollments to 1980 are calculated by the National Science Foundation and the effects of both projections on mean library expenditures result in either a continuing decrease or a return to increasing expenditures per scientist or engineer.

Figure 39

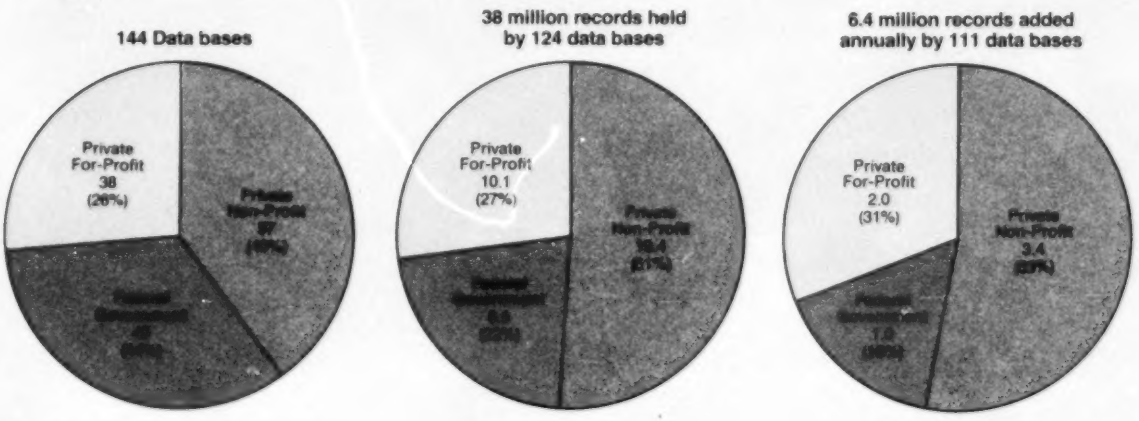
Library S&T information expenditures per U. S. scientist or engineer*, in 1972 constant dollars (1960-1980)



The creation of bibliographic data bases is the primary activity of abstracting and indexing services. Of a total of 144 U.S. scientific and technical data bases, 40 percent are produced by private, non-profit organizations. The Federal Government produces 34 percent. In terms of annual input of data-base records, the non-profit sector is adding more than government and for-profit organizations combined. The result, in terms of cumulative number of records, is that the private non-profit sector makes available half of the total, with the other half almost equally available from government or profit-making organizations.

Figure 40

S&T bibliographic data bases; number, annual input and cumulative number of records, by sector, 1975


144 Data bases
Private For-Profit 38 (26%)
38 million records held by 124 data bases
Private For-Profit 10.1 (27%)
6.4 million records added annually by 111 data bases
Private For-Profit 2.0 (31%)

SOURCE: Based on Williams & Rouse, *Computer-Readable Bibliographic Data Bases: A Directory and Data Sourcebook*, 1976

■ Federal investment in S&T information transfer amounted to almost $5 billion in 1975. Federal contributions represented over 40 percent of the $10.9 billion total. The largest proportion of these Federal resources, 41 percent, are attributed to the use of information. Federal libraries, Federal numeric data activities and support for authorship were the other main functions included in Federal expenditures. The smaller amount for publishing is consistent with the finding that to a great extent the research supported by Federal Government yields articles and books published by other sectors.

Figure 41

Federal share of S&T communication costs, 1975

(Billions)

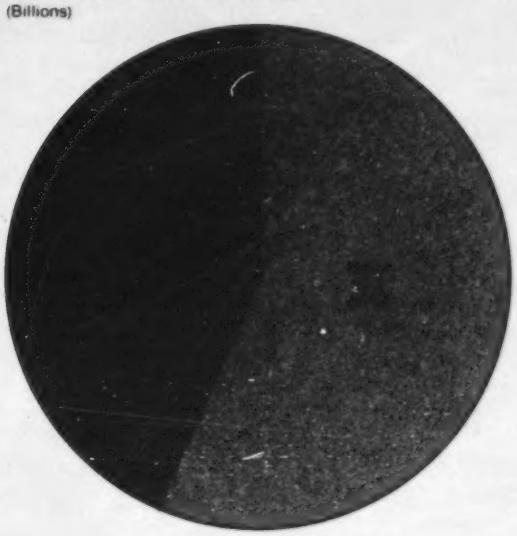
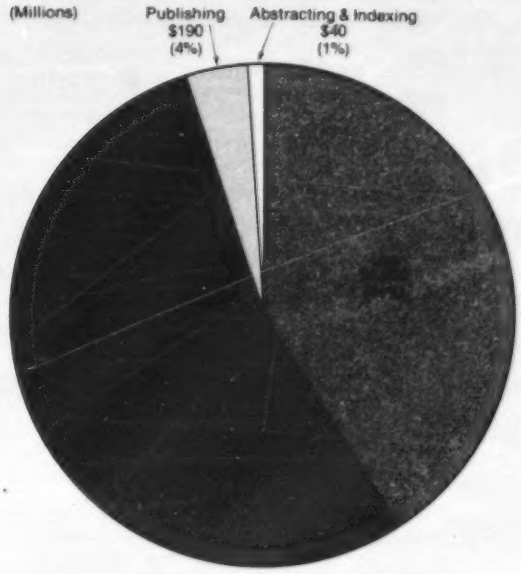


Figure 42

Federal S&T communication costs by function, 1975



■ The $620 million Federal support for S&T authorship goes primarily for preparation of periodical articles. Thus federally supported authorship accounts for approximately 38 percent of all authorship.

The Federal support for all publications, $190 million in 1975, is 11 percent of all S&T publications expenditures, and goes primarily for publication of periodicals.

Figure 44

Federal support for S&T publication, by medium, 1975

(Millions of dollars) $190 million total

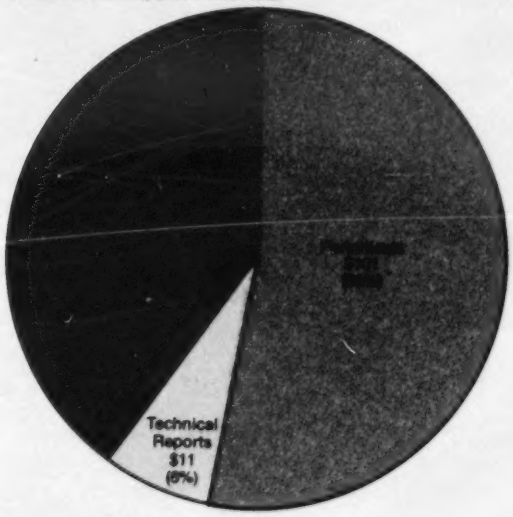
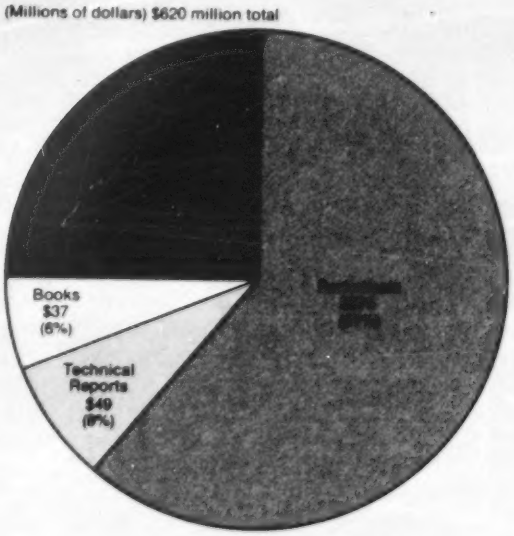


Figure 43

Federal support for S&T authorship, by medium, 1975

(Millions of dollars) $620 million total



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